NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

IRRIGATION WATER CONVEYANCE LOW-PRESSURE, UNDERGROUND, PLASTIC PIPELINE

(No.)
CODE 430-EE

DEFINITION

A pipeline and appurtenances installed in an irrigation system.

PURPOSE

To prevent erosion or loss of water quality or damage to land, to make possible the proper management of irrigation water and to reduce water conveyance losses.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to underground thermoplastic pipelines ranging from 4 inch to 24 inch in diameter that are subject to internal pressures of up to 50 lb/in^2. Plastic pipelines requiring a pressure greater than 50 lb/in^2 shall be designed according to the requirements of Practice Standard High Pressure Underground Plastic Pipeline, 430-DD. This standard applies to pipelines with stands and vents open to the atmosphere and to pipelines not open to the atmosphere but provided with pressure relief valves and combination air-vacuum valves.

All pipelines shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system designed to facilitate the conservation use and management of the soil and water resources on a farm or group of farms.

Water quantity and quality and rates of irrigation delivery for the area served by the pipeline shall be sufficient to make irrigation practical for the crops to be grown and the water application method to be used.

Plastic pipelines installed according to this standard shall be placed only in suitable soils where the bedding and backfill requirements can be fully met by on site materials or select materials transported to the site.

DESIGN CRITERIA

All planned work shall comply with all Federal, State, and local laws and regulations.

Working pressure and flow velocity. The pipeline shall be designed to meet all service requirements without a static or working pressure, including hydraulic transients, at any point greater than the maximum allowable working pressure of the pipe used at that point. The static or working pressure of pipelines open to the atmosphere shall include freeboard. For all pipelines controlled by in-line valves, valves at the outlet or pumps, the design working pressure shall not exceed 72 percent of the pressure rating of the pipe. Flow velocities in pipelines with in-line valves and/or pumps shall not exceed 4 feet per second unless the design includes an analysis of the potential surge conditions.

The maximum allowable working pressure for low-head plastic irrigation pipe shall be 50 feet or 22 lb/in^2. Pipelines constructed of plastic irrigation pipe (PIP) or IPS size pipe covered by this standard shall have a working pressure no greater than 50 lb/in^2.

For pipelines conveying water warmer than 73.4 degrees F, the allowable working pressure shall be adjusted in accordance with Table 1.

Friction losses. For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation, using a roughness coefficient ‘C’ equal to 150.

NRCS, IDAHO
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Table 1. Pressure Rating Factors for PVC and PE Pipe for Water at Elevated Temperatures (Deg.) F

Temperature	PVC	PE
73.4	1.00	1.00
80	0.88	0.92
90	0.75	0.81
100	0.62	0.70
110	0.50	-
120	0.40	-
130	0.30	-
140	0.22	-

NOTE: Reduce pipe pressure rating for warm water equals pressure rating at 73.4 degrees F times factor for appropriate water temperature.

Capacity. The design capacity of the pipeline shall be the larger of:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive irrigation demand of the crop or crops to be irrigated.
2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

Outlets. Appurtenances required to deliver water from the pipe system to the land, to a ditch or a reservoir or to any surface system are defined as outlets. Outlets shall have adequate capacity at design working pressure to deliver the required flow to (1) the hydraulic gradeline of a pipe or ditch, (2) a point at least 6 inches above the field surface, or (3) the design surface in a reservoir.

Check Valves. A check valve shall be installed between the pump discharge and the pipeline where backflow may occur. As needed anti-siphon devices shall be designed on pipelines that convey chemicals, pesticides or animal waste. Such devices shall meet the requirements of the Idaho State Department of Agriculture.

Stands open to the atmosphere. Stands shall be used wherever water enters the pipeline system to avoid entrapment of air, to prevent surge pressures, to avoid collapse because of negative pressures and to prevent the pressure from exceeding the maximum allowable working pressure of the pipe and at other points as needed/desired to control head in the pipe or for outlets. Stands shall be constructed of steel pipe, concrete pipe, plastic pipe, corrugated metal pipe or other approved material and be supported on a base adequate to support the stand and prevent movement or undue stress on the pipeline. Open stands shall be design to meet or exceed the following criteria:

1. Each stand shall allow at least 1 foot of freeboard above design working head. The stand height above the centerline of the pipeline shall be such that the static or the design working head plus freeboard does not exceed the allowable working pressure of the pipe.
2. The downward water velocity in inlet stands should not exceed 1 feet per second and shall not exceed 2 feet per second. The inside diameter of any inlet stand shall not be less than one pipe diameter larger than the diameter of the pipeline.
3. If the water velocity in the inlet pipeline or ditch to the stand exceeds three times the velocity in the pipeline exiting the stand, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet equal to the sum of the diameters of the inlet and outlets.
4. The cross-sectional area of stands to dissipate surge pressure may be reduced above a point a minimum of 1 foot above the top of the higher of the inlet or outlet pipe, but the water velocity in the reduced cross-section shall not exceed 10 feet per second if the entire design flow were discharging through the stand.
5. Vibration control measures, such as special couplers or flexible pipe, shall be provided as needed to insure that vibration from pump discharge pipes is not transmitted to stands.

Sand traps, when combined with a stand, shall have a minimum inside diameter of 30 inches and shall be constructed so the bottom is at least 24 inches below the invert of the outlet to the pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 feet per second.

Stands with gates for controlling water shall be large enough to facilitate installation and repair of gates. Stands with multiple pipes and/or gates shall be sized large enough to facilitate installation while maintaining required structural strength of riser.

Vents. Vents must be designed into pipelines open to the atmosphere to provide for the removal and entry of air. They shall:

1. Meet the freeboard requirements for stands open to the atmosphere.
2. Have a cross-sectional area at least one-half the cross-sectional area of the pipeline (both inside measurements) for a distance of at least one pipeline diameter up from the centerline of the pipeline. Above this elevation the vent may be reduced to 2-inch diameter.
3. Locate a vent or outlet at the downstream end of each pipeline or lateral, at points where there are changes in grade in a downward direction of flow of 10 degrees or more, at all high points along the pipeline, at points along the pipeline where during filling or operation of the pipe a change in grade results in the pipe flowing partially full following a full pipe reach and at a maximum spacing of 1300 feet along reaches of pipelines with no open outlets.

Stands closed to the atmosphere. Where pressure-relief valves and air-and-vacuum valves are used instead of open stands, all requirements under "Stands Open to the Atmosphere" shall apply except as modified as follows. The inside diameter of the closed stand shall be equal to or greater than that of the pipeline for least 1-foot above the top of the highest inlet or outlet pipe. Above this point the cross-sectional area of the stand may be reduced but the water velocity in the reduced cross-section shall not exceed 10 feet per second if the entire design flow were discharging through the stand. On pump locations not requiring a vertical offset between the pump discharge pipe and the pipeline the discharge may be doglegged below ground, the stand shall extend at least one foot above the highest part of the pump discharge pipe.

Pressure-relief valves and air-and-vacuum relief valves shall be installed on the riser using no less than nominal pipe sized to match the threaded inlet of the respective valve.

Air-release valves. The three basic types of air-release valves used under this Practice Standard are described as follows:

1. An air-release valve, a continuously acting valve that has a small venting orifice, generally ranging between 1/16 and 3/8 inch in size. This valve releases pockets of air from the pipeline once the line is filled with water and working under pressure.
2. An air-and-vacuum valve, sometimes called air-vacuum-release valve or an air-vent-and-vacuum relief valve, this valve has a large venting orifice and exhausts large quantities of air from the pipeline during filling and allows air to reenter the line and prevents a vacuum from forming during emptying of the pipeline. This valve does not allow further escape or release of air once the valve closes.
3. A combination air valve, sometimes called combination air-release and air-vacuum valve or combination air-and-vacuum-relief valve is continuous acting and combines the functions of both the air-release valve and the air-and-vacuum valve in one valve body.

On closed to the atmosphere pipelines and on closed stand pipes on open to the atmosphere pipelines, air-and-vacuum valves or combination valves shall be installed at all summits, at the entrance and at the end(s) of pipelines when needed to provide a positive means for air escape during the filling and air entry during the draining of the pipeline. Such valves generally are needed at theses locations if there are no other features such as permanently located open outlets, stands or vents to adequately permit air flow into and out of the pipeline at the particular location during filling and emptying operations.

The diameter of the orifice (opening that controls air flow during filling or emptying) of an air-and-vacuum relief valve shall equal or exceed that specified as follows for the appropriate diameter of pipeline:

Diameter of Orifice (in)	Diameter of Pipeline (in)
1	4
1-1/4	6
1-3/4	8
2-1/4	10
2-3/4	12
3-1/2	15
4	18
5	21
6	24

Air-release valves or combination air valves shall be used as needed to permit air to escape from the pipeline while the line is working at pressure. Small orifices of these types of valves shall be sized according to the recommendations of the manufacture for the working pressure and the venting required.

Air release and air vacuum valves shall be installed in conjunction with in-line valves to allow the removal or entry of air as required on each side of the valve in an open or closed position.

Manufacturers of air release valves marketed for use under this standard shall provide dimensional data, which shall be the basis for the selection and acceptance of these valves.

Pressure-relief valve. Pressure relief valves can be used on low-pressure plastic pipelines as an alternative to stands open to the atmosphere. A pressure-relief valve shall be installed upstream of any in-line gate, Butterfly valve or other type of in-line valve. Pressure-relief valves shall be installed on the discharge side of any check valve and in-line valve where a reversal of flow may occur and at the end of the pipeline if needed to relieve surge at the end of the line. Pressure-relief shall be set to open at a pressure no greater than 5 psi above the rated pressure of the pipe or 50 psi whichever is smaller. The flow capacity of pressure-relief valves shall be the pipeline design flow rate with a pipeline pressure no greater than 50 percent above the permissible working pressure for the pipe. The pressure at which the valves start to open shall be marked on each pressure-relief valve. Adjustable pressure-relief valves shall be sealed or otherwise altered to prevent changing pressure from that marked on the valve. Manufacturers of pressure-relief valves marketed for use under this standard shall provide capacity tables, based upon performance tests, that give the discharge capabilities of the valves at the maximum permissible pressure and differential pressure settings. Such tables shall be the basis for design of pressure setting and acceptance of a valve.

Thrust Control. Thrust control shall be provided as needed at points where the horizontal or vertical alignment change is 15 degrees or greater, at tees, pipe reductions, dead ends and at in-line control gates. Adequate anchorage shall be provided, regardless of joint type, when the pipeline is on a slope of 45 degrees and greater.

Thrust blocks shall be large enough to withstand the forces tending to move the pipe, including those of momentum and pressure as well as forces due to expansion and contraction. When available, the pipe manufacturer's recommendations regarding thrust control shall be followed. In the absence of specific pipe manufacturer's requirements, the following formulas shall be used in designing thrust blocks:

for bends $$A = \frac{98\ H\ D^2}{B} \sin\frac{a}{2}$$

for dead ends and tees $$A = \frac{49\ H\ D^2}{B}$$

for reducers $$A = \frac{98\ H\ (D^2 - d^2)}{B}$$

Where:

A = Area of thrust block required (ft^2)
H = Maximum working pressure (ft)
D = Inside diameter of pipe (ft)
d = Inside diameter of smaller pipe (ft)
B = Allowable passive pressure of soil (lb/ft^2)
a = Deflection angle of pipe bend

When soil tests are not available, the passive soil pressure may be estimated from Table 2.

Table 2 - Allowable Soil Bearing Pressure (lb/ft^2)

Natural Soil Material	Depth of cover to center of thrust block			
	2 ft	3 ft	4 ft	5 ft
- Sound bedrock	8,000	10,000	10,000	10,000
- Dense sand & gravel (assumed 0 = 40^0)	1,200	1,800	2,400	3,000
- Dense fine to coarse sand (assumed 0 = 35^0)	800	1,200	1,650	2,100
- Silt & clay mixture (assumed 0 = 25^0)	500	700	950	1,200
- Soft clay & organic soils (assumed 0 = 10^0)	200	300	400	500

Thrust blocks shall be constructed of concrete by filling the entire space between the pipe and an undisturbed trench wall. Steel reinforcement is optional in thrust blocks, which require a bearing area of less than 4 D^2 (where D is the pipe diameter). Larger thrust blocks shall be reinforced with a minimum of #4 bars at 8 inch c-c.

External Loading. Deflections in the pipe caused by external loads shall not exceed 5 percent of the diameter. Idaho Technical Note #7 or similar reference shall be used to determine predicted deflection for site loading conditions. Public road crossings shall have a carrier pipe.

Joints and connections. All joints and connections shall be designed to withstand the design maximum working pressure of the pipeline without leakage and leave the inside of the pipe free of obstruction that may tend to reduce its capacity. Fittings made of steel or other metal shall be protection from corrosion by a protective coating such as plastic tape wrap, coal tar-epoxy or other corrosion resistant coating. Designs of pipelines with solvent welded joints shall include expansion couplers at a spacing not exceeding 400 feet, except expansion couplers are not required on pipe reaches including risers at 200 feet or less spacing. The maximum distance between a coupler and the nearest fixed point, such as a tee, bend or riser, shall be 200 feet. Expansion couplers shall have a minimum length of 14 inches and provide 10 inches of contraction.

In-line valves. In-line valves shall be equipped with geared operators.

Draining and flushing. Provisions shall be made for completely draining the pipeline where freezing is a hazard. As needed drains will be provided at low points along the pipeline or provisions shall be made to empty the pipeline by pumping.

Materials. The compound used in manufacturing the plastic pipe shall meet one of the following requirements:

1. Polyvinyl chloride (PVC) shall be as specified in ASTM D 1784 for Code Classification 12454-B, 12454-C or 14333-D.

2. Acrylonitrile-butadiene-styrene (ABS) shall be as specified in ASTM D 1788 for Code Classification 5-2-2, 3-5-5 or 4-4-5.

3. Polyethylene (PE) shall be as specified in ASTM D 1248 for Code Classification, IIC-P23, IIIC-P33 or IVC-P34.

Iron pipe size (IPS) plastic pipe and I.D. controlled PE pipe meeting one of the following ASTM specifications are acceptable under this Practice Standard.

ASTM	SPECIFICATION
D 1785	Polyvinyl Chloride Plastic Pipe, Schedule 40,80 and 120
D 2241	Polyvinyl Chloride Pressure Rated Pipe
D 2672	Joints for IPS PVC Pipe Using Solvent Cement
D 2740	Polyvinyl Chloride Plastic Tubing
D 1527	Acrylonitrile-Butadiene-Styrene Plastic Pipe, Schedules 40 and 80
D 2282	Acrylonitrile-Butadiene-Styrene Plastic Pipe
D2104	Polyethylene Plastic Pipe, Schedule 40
D 2239	Polyethylene Plastic Pipe Based on Controlled Inside Diameter
D 2447	Polyethylene Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
D 2737	Polyethylene Plastic Tubing

D 3035 Polyethylene Plastic Pipe Based on Controlled Outside Diameter
F 771 Polyethylene Thermoplastic High-Pressure Irrigation Pipeline Systems

Plastic irrigation pipe (PIP) shall meet the requirements of ASTM D 2241 or of ASTM D 2282 except that:

1. The outside diameters, wall thicknesses and tolerances in ASAE S376.1 "Design, Installation and Performance of Underground, Thermoplastic Irrigation Pipelines" shall apply.

2. The minimum burst pressure requirements for water at 23 degrees C for PVC 1120 and 1220 plastic pipe, SDR 51 is 260 lb/in^2 and for ABS plastic pipe SDR 32.5 and SDR 41 is 380 and 300 lb/in^2.

Product Marking. Pipe shall be marked in accordance with the requirements of ASTM D 2241 showing nominal pipe size, type of plastic material, pressure rating, ASTM specification and manufacturer's trademark.

Fittings and Couplers. All fittings and couplers shall meet or exceed the same strength requirements as those of the pipe and shall be of material that is recommended for use with the pipe.

Solvent cement joints. Solvent for solvent cement joints shall conform to ASTM D2564 for PVC fittings and to ASTM D 2235 for ABS pipe and fittings.

Rubber gasket joints. Rubber gasket joints shall conform to ASTM D 3139.

Depth of cover. Pipe shall be installed at sufficient depth below ground surface to provide protection from hazards imposed by road traffic and farm crossings, farming operations, freezing temperatures or soil cracking. The minimum depth of cover for pipe susceptible to any of these hazards shall be 30 inches.

In areas where the pipe will not be susceptible to freezing and vehicular or cultivation hazards and the soils do not appreciably crack the minimum depth of cover may be reduced to:

Pipe diameter (inch)	Depth of cover (inch)
4 through 6	18
more than 6	24

At low places on the ground surface, extra fill may be placed over the pipeline to provide the minimum depth of cover. The top width of the fill shall be no less than 10 feet and the side slopes no steeper than 6:1.

Trench. The trench below the top of the pipe shall be only wide enough to permit the pipe to be easily placed and joined and to allow the initial backfill material to be placed under the haunches of the pipe. The maximum trench width shall be 30 inches greater than the diameter of the pipe. If the trench is precision excavated and has a semicircular bottom that closely fits the pipe, the width shall not exceed the outside diameter of the pipe by more than 10 percent.

The trench bottom shall be uniform so that the entire length of the pipe has contact with soil without bridging. If rocks, boulders or any other material that can damage the pipe are encountered, the trench bottom shall be undercut a minimum of 4 inches below final grade and filled with bedding material.

Backfill. Hand, mechanical or water packing methods may be used.

For pipe 18-inch diameter and smaller the initial backfill shall be soil or sand that is free of rocks, gravels and clods larger than 1 inch in diameter. For pipe larger than 18 inch diameter the initial backfill shall be angular 1 to 1/4 inch size grade crushed stone with a maximum of 10 percent noncohesive fines or sands and gravels with a maximum particle size of 1 inch containing a maximum of 12 percent noncohesive fines and sands with a maximum of 45 percent passing a #40 sieve.

Final backfill. The final backfill shall be free of large rocks, frozen clods and other debris larger than 3 inches in diameter.

All special backfill requirements of the pipe manufacturer shall be met.

Testing. The pipeline shall be tested for leakage and proper functioning. The tests may be performed before backfilling or anytime after the pipeline is ready for service.

Certification and guarantee. The installing contractor shall certify that his/her installation complies with the requirements of this standard. The Contractor shall furnish a written guarantee that protects the owner against defective workmanship and materials for a period of not less than 1 year. The certification shall identify the pipe manufacturer and markings on the pipe being supplied.

CONSIDERATIONS

In soils subject to cracking and/or sloughing or where trench excavation depths exceed 5 feet include provisions for shoring or sloping sides of the trench per applicable OSHA Regulations.

Where differential settlement can create a concentrated loading on the pipe, as at the connection of a buried pipe to a rigid structure consider a flexible joint in the pipe adjacent to the structure.

Consider effects on the water budget, especially on volumes and rates of runoff to downstream water users.

Consider the effects on wetlands and water related wildlife.

Consider effects on water flows and aquifers and the affect to other water uses and users.

Consider the potential effect on irrigation water management.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared to show site specifics. The drawings and specifications shall show pipe location, pipe type, pressure classes and sizes, details for appurtenances including type, stand and vent requirements, pressure class (settings) size and locations for valves, thrust block locations and sizes and trench/backfill requirements as applicable.

OPERATION AND MAINTENANCE

The operation and maintenance of the system shall include typical items of flushing pipe, cleaning and repairing appurtenances etc.

REFERENCES

- Engineering Field Manual

  Chapter 3, Hydraulics

  Chapter 15, Irrigation

- NRCS Conservation Practices

  Structure for Water Control, Code 587

  Irrigation System, Trickle, Code 441

  Irrigation System, Sprinkler, Code 442

  Irrigation System, Surface and Subsurface, Code 443

  Irrigation System, Tailwater Recovery, Code 447

  Irrigation Water Conveyance, Irrigation Pipeline, Code 430AA to 430JJ

- ASAE Standard: ASAE S376.1, Design, Installation and Performance of Underground, Thermoplastic Irrigation Pipelines

- Idaho State Department of Agriculture, “Rules Governing Pesticide and Chemigation Use and Application”